ISMAIL AL JAZARI MACHINES AND NEW TECHNOLOGIES

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Abstract: Al-Jazari was a 12th Century Turkish Scientist, Engineer and writer. His full name was Badi Al-Zaman AbulI-Izz Ibn Ismail Ibn Al-Razzaz Al-Jazari. He lived in Diyarbakir region in Turkey (1206 AD). As his town name is Cizre, the modern Turkish scripting of Jizra , his last name is known as Jazari (Uzun, 1997). Badi Al Zaman means "prodigy of the Age" and was applied to other well-known men (Hill, 1974). He served the Artuks a Seljuks dynasty in Diyarbakir, as a chief engineer – as did his father before him. He invented the crankshaft and some of the first mechanical clocks, driven by water and weights- used water power. He authored and drawed 60 inventions in his book "Al-Jami Bain Al-Ilm Wal-Amal Al-Nafi Fi Sinat'at Al-Hiyal" (The Book of Know-ledge of Ingenious Mechanical Devices). Kitab al-Hiyal is an interesting work on automatic control mechanism, fountains, devices, pipes, valves and siphons. The importance and originality of Kitab al-Hiyal is due to its being an earlier example of the automatic control studies in the history. There are a number of manuscripts of Jazari's work in Oxford, Leiden, Paris, Dublin and İstanbul. Equally cranks may have first been documented by Al Jazari – 300 years before western engineers achieved this (Francesco di Giorgio Martini and Leonardo Da Vinci). He used some kind of symbols for understanding of his drawings like using of electronic circuits. We found that his machine drawings and manufacturings quite qualified understanding (http://orionrobots.co.uk/tiki-index.php?page=Al+Jazari). The aim of this study is to review and examine Al Jazari's drawings and then, to compare and examine with the new technology period.

1. INTRODUCTION

Abu Al Izz Ismail al Jazari lived in Amid, that is called now Diyarbakir in South-east of Anatolia in Turkey, (12th century) during Artuk Seljuqs period. He had spent twenty-five years in service of Seljuqs Sultans (Nasiruddin Abul Fath Muhammed bin Karaaslan and his father).

The Artuks were a Turcoman dynasty descended from Artuk, a general who served Malik Shah, the Seljuq Sultan, at the end of the 5th/11th century. They were divided into two main branches, descended from two sons of Artuk-Ilghazi and Sukman. Al Jazari's masters belonged to the Sukman branch of family (Hill, 1974).

We know from his book that Al-Jazari wrote that book, which finished (16th jan . 1206), on the request of Sultan Nasiral-Din Mahmud bin Karaaslan after spending twenty five years in his service (1198). Al-Jazari wrote his book in Arabic alphabet that was dynasty palace's language at that time.

He frankly acknowledged that he got some knowledge from the formers such as Archimedes. "I have studied the books of the earlier (scholars) and the works of the later [craftsmen]-masters of ingenious devices with movements like pneumatic (movements), and water machines for the constnat and solar hours, and the transfer by bodies of bodies from their natural positisons.I have contemplated in isolation and in company the implications of proofs. I considered the treatment of this craft for a period of time and I progressed, by practising it, from the stage of book learning to that of witnessing and I have taken the view on this matter of some of the ancients and those more recent (scholars). I was fervently attached to the pursuit of this subtle science and persisted in the endeavour to arrive at the truth. The eyes of opinion looked to me distinguish myself in this beloved science. Types of (machines) of great importance came to my notice, offering possibilities for types of marvellous control.

His book showed a deep understanding, and is still analyzed today by the world's top engineers. Prof. Lynn White Jr. writes: "Segmental gears first clearly appear in Al-Jazari, in the West they emerge in Giovanni de Dondi's astronomical clock finished in 1364, and only with the great Sienese engineer Francesco di Giorgio (1501) did they enter the general vocabulary of European machine design" (http://en.wikipedia.org/wiki/Al-Jazari).

I assembled that in a book (lit. Introduction Mugaddima) comprising fifty specimens and it is divided into six categories. I have been thorough in description and in particulars. In what I have written I have used foreign names passed on by earlier people and adherence to these has continued until to today; and other expressions made necessary by time. For the people of every epoch have [their own] language and every group of scholars have technical terms understood among themselves, and convertions familiar to them. For every specimen (shakl) I have drawn a picture, and have marked it with letters for guidance and have (also) put altenatives for these letters.

Catergory I. On the construction of clocks from which can be told the passage of the constant and solar hours-10 Charpters (it.specimens-ashkal).

Catergory II. On the construction of of vessels and figures suitable for driking sessions-10 Charpters.

Catergory III.On the construction of pitchers and basins for phlebotomy and ritual washing-10 Charpters.
Catergory IV. On the construction in pools of fountains which change their shape and of machines for the perpetual flute -10 Charpters.
Catergory V. On the construction of machines for raising water from standing water which is not deep and from a running river-5 Charpters.
Catergory VI. On the construction of different, dissimlar things -5 Charpters" (Uzun, 2003).

But according to Al-Jazari, some of these knowledge are correct some are not. Al-Jazari described approximately fifty mechanical devices in six different categories, including water clocks (one of his famous clocks was reconstructed successfully at the London Science Museum in 1976 and Istanbul Technical Universty in 1982), automata, combination locks, hand washing device (Wudhu machine) , machines for raising water, double acting pumps with suction pipes and the use of a crank shaft in a machine, accurate calibration of orifices, lamination of timber to reduce warping, static balancing of wheels, use of paper models to establish a design, casting of metals in closed mould boxes with green sand, and more. He is also regarded as one of the first recorded designers of a humanoid robot (cybernetics).

First his work was machine of Wudhu (preparing top ray, washing hands and face etc. before salah) for Sultan. Sultan admired his machine and asked him to write a book. That was claimed the first of his manuscript. There are a number of manuscripts of Al Jazari's work, which are available in İstanbul, London, Paris, Dublin, Leiden etc.

Ibn Ismail Ibn al-Razzaz Al-Jazari (1206 AD) was one of history's greatest engineers. He invented many automata and some of the first mechanical clocks, driven by water and weights. He was called Al-Jazari after the area where he was born. Since the pre-Islamic times, al-Jazira has been an economically prosperous region with various agricultural (fruit and cereal) products, as well as a prolific manufacturing (food processing and cloth weaving) system. Al-Jazira, which is the traditional Arabic name for northern Mesopotamia or Jazira is a town in the south-east Anatolia in Turkey (near Diyarbakir). His tomb is in that town. Al-Jazari draws on the works of its predecessors both from the Greeks (Philon, Heron and Archimedes) and Islamic scholars and engineers (Banu Musa brothers, Al-Khuwarizmi and Ridwan). His contribution was very important for the diffusion of knowledge in the Arabic world and after in Europe due to the translations of his books like "The Book of Knowledge of Ingenious Mechanical Devices" which contains more than 150 automata and mechanical devices.

Eilhard Wiedemann was the first most important researcher studied on Al Jazari's works. He (1852-1928) studied on Islamic science, medicine, mathematics and technology his life's work, and in these fields his writings are of great importance. His many articles are scattered among a number of learned German Periodicals. He was worked with Fritz Hauser, a German engineer. Al Jazari's works were examined by Wiedemann and Hauser in seven articles in various periodicals. These articles have several merits, and in particular they give a fairly clear understanding, to anyone with some measure of technical knowledge, of the design, construction, and operation of each of devices (Hill, 1974).

In 1974 Donald R. Hill translated and annotated Al Jazari's book in Boston –USA. His manuscripts were translated, and drawings additionally guieded to understanding. That book name is "The Book of Knowledge of Ingenious Mechanical Devices".

In 1951, Ibrahim Hakki Konyali for the first time mentioned about that manuscript in a magazine in Turkey. Dr. Ayhan Songar, Dr. Toygar Akman wrote about Al Jazari's work. Prof. Dr. Kazim Çeçen made one of Al jazari's machines (Water Clock) in Istanbul Technical Universty in 1980's. Prof. Dr. Atilla Bir wrote some article about his life and Works. 1997 first book was puplished in Konya about Al Jazari's life and his Works by Abdullah Uzun then 2004 his manuscripts full translated in Turkish.

2. HIS MACHINES IN COMPARISON TO SOME NEW TECHNOLOGIES

The first water clocks in their simplest form were used by the ancient civilizations of Babylonia and Egypt (Hill, 1974). After and before Al Jazari, a lot of water clocks and ingenious devices made in Asia Minor, Philon of Byzantium and Arabs. Some of those technologies was transferred to Spain and to Maghrib (Andalusia).

Al-Jazari's book delt with completely devices and automatas for multiple functions. What they have in common is the considerable degree of engineering skill required for their manufacture, and the use of delicate mechanisms and sensitive control systems. Many of the ideas employed in the construction of ingenious devices were useful in the later development of mechanical technology. Al-Jazari inherited the knowledge of his predecessors, but he improved on their designs and added devices of his own invention (http://www.history-science-technology.com/Articles/articles%206.htm).

Al-Jazari use some symbols like electronics works in his manuscript. He wrote and designed his machine very carefully. Pictures are nice and colours are not pale that are of great artistic merit. Some historians of art acknowledges that his manuscripts were illustrated in marvelous form and conditions.

Being honest and humble, he always expressed that he had got some technical principle from Archimedes and other previous scientists.

In 1206, Al-Jazari presented his "Book of Knowledge of Ingenious Mechanical Devices", devised for both educational and entertanment purposes, to the Sultan. In this singularly important work, he described contemporary labor-saving devices and unusual clocks, including some of his own designs. Even though the book does not contain descriptions of the astrolabe or balance, for which Arab scientists were famous, it plainly displays stronger and weaker aspects of Arabic engineering.

Most of the machines, with varying degrees of utility, used age-old principles of mechanics, including systems of weights, pulleys, gears, cams, and levers. The crankshaft was first described Al-Jazari, though it is not clear whether

or not it has been invented by him. In fact, some scientists say that he invented the crankshaft and some of the first mechanical clocks, driven by water and weights (http://en.wikipedia.org/wiki/Al-Jazira%2C_Mesopotamia Minor).

Fig. 1. Mechanical pump by Jazari

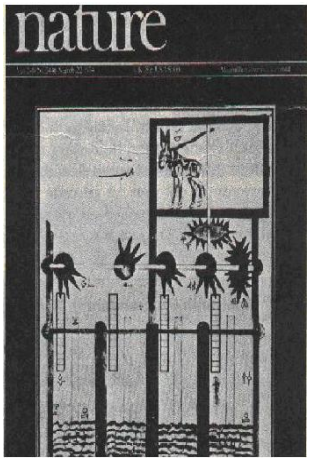

Fig. 2 Al-Jazari in the Nature magazine

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Equally cranks may have first been documented by Al Jazari 300 years before Western Engineers achieved this (Francesco di Giorgio Martini and Leonardo Da Vinci) (http://en.wikipedia.org/wiki/Al-Jazira%2C_Mesopotamia_Minor).

Al-Jazari noted a number of practical joke devices in his text. Some were trick drinking vessels that appeared to contain water but could not be emptied. Others looked empty but produced water when tipped over.

In producing these not-so-useful inventions, Al-Jazari was typical of his age. The engineers of that time had a reputation for frivolous machines that dated back to the writings of the ancient Greeks. Had he lived in a different society, Al-Jazari might have put his ingenuity to a different purpose.

In Fig. 1, there is an automata for rotation gearwheels by means of water. Water flows into second section then axle and gearwheel rotates, so it triggers the other gear-wheel and rotation of the vertical axle and then, the rotation of the robot donkey, cupboard turning and rising water at last. This cycle is going as sketched in Fig. 1.

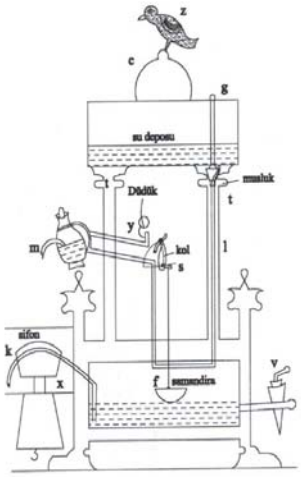

Fig. 3. Automatic Wudhu machine

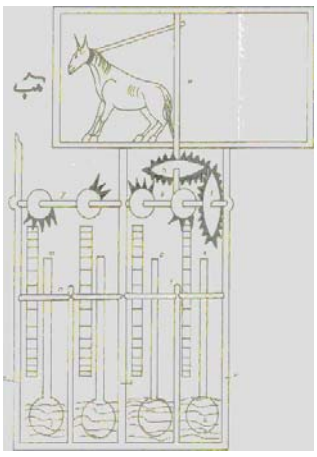

Fig. 4. 4 Effective water rising system (4 stroke cylinder)

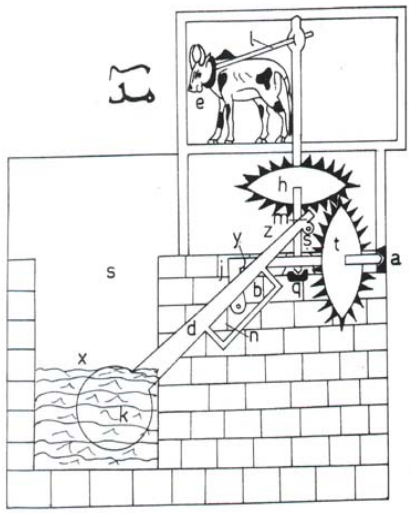

Fig. 5. Crank shaft system water rising machine

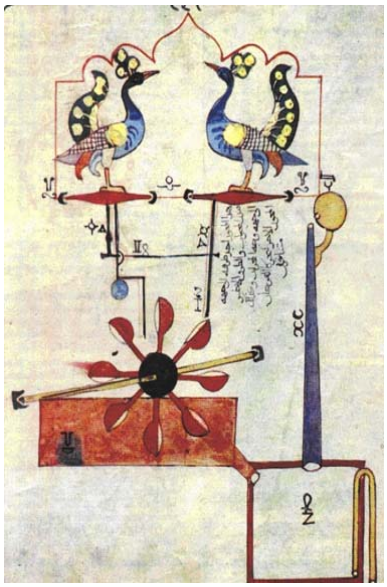

Fig. 6. Water Clock

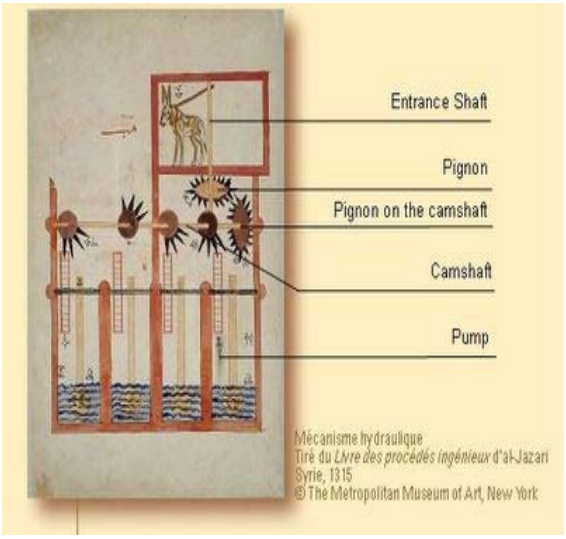

Fig. 7. Four effective water rising system

3. CONCLUSION

Al-Jazari's works and his book occupies an important place in the history of automata, mechanics, mechatrconics, automatic control, robotics and automated musical theaters. His pioneering work is duly acknowledged in most histories.

Al-Jazari was not primarily innovator, but this is not to imply that he made no innovations like this; the perfection of the tipping bucket, the reciprocating pump, measuring basin and some type of water clock. We should also include in his significant innovations his remarks that indicate that he had ideas about application of an escapement to a water-wheel (Hill, 1974).

The life stories of engineers such as Leonardo da Vinci, James Watt and many other scientists including their contributions are quite well known, but it is not very much known about Al Jazari's life. Today there is only Al Jazari's manuscript. As such, none of European scientists do know him nor his works, thus a substabtial attention is needed to be drawn on his possible impacts upon later generations of engineers. Al Jazari's idea and useful machines are in his manuscript but after him no-one has written and followed about him and his works. His drawings are shown with several remarks. He certainly used a technique that is indispensable for all engineering drawing.

Al Jazari, then, gives us the full engineering content of his work. For a given machine he tells us its appearance, purpose and functioning. He describes, step by step, the manufacture of its component parts, setting out, assembly and fitting, joints and connections, and testing. He was a master craftsman, fully conversant with all branches of his trade, consciously proud of his membership of the technical fraternity

REFERENCES

1. **Hill D. R.** (1974), *The Book of Knowledge of Ingenious Mechanical Devices*, Boston, USA.
2. **Uzun A. (**1997), *Cizreli Eb-Ul-İz ve Otomatik Makinaları*, Esra Yayınları Konya.
3. **Uzun A.** (2003), Cizreli Eb-Ul-Iz ve Otomasyon Sistemleri, UMTS, Gazi Üniversitesi, Ankara, Turkey.
4. http://en.wikipedia.org/wiki/Al-Jazari
5. http://en.wikipedia.org/wiki/Al-Jazira%2C_Mesopotamia Minor.
6. http://orionrobots.co.uk/tiki-index.php?page=Al+Jazari
7. http://www.history-science-technology.com/Articles/articles%206.htm